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July 21, 1989

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and Engineering
35 Nagog Park
Acton, Massachusetts 01720
508-635-9500

Ms. Mary Kay Voytilla
U.S. Environmental Protection Agency
JFK Federal Building
Boston, MA 02203

Re: Residential Indoor Air Sampling Results: Dewey Avenue Neighborhood, Wells G&H Superfund Site

Dear Ms. Voytilla:

As you know, Unifirst and Grace have requested a team of consultants to conduct an indoor air monitoring study in the Grace and Unifirst buildings and three Woburn homes. This study was carried out in conjunction with EPA's indoor air measurements in the three homes to allow direct comparisons between the data sets and enhance the value of each study alone. The enclosed report presents the current findings of the air quality study in the three residences.

We are providing this report at the request of our clients for your use in interpreting the indoor air quality in the three subject homes. Please call either of the undersigned, should you have any questions regarding this report.

Sincerely,

for Douglas Smith MK

Douglas G. Smith, Sc.D.
Principal Scientific Consultant
ENSR Consulting and Engineering

John D Spengler

John D. Spengler, Ph.D.
Principal Scientist
Environmental Health and Engineering, Inc.

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545239.AS, 3140-001-011

July 21, 1989

WOBURN INDOOR AIR MONITORING PROGRAM

Introduction

In early April, the Massachusetts Department of Public Health (DPH) made public its February 7, 1989 draft report on its review of health and safety issues related to the Massachusetts Wells G&H Superfund Site. In this report, it was suggested that groundwater contaminants might be migrating up through the soil into the basements of some Woburn homes and/or the Unifirst and W.R. Grace buildings in the area. In order to address this question, Unifirst and Grace asked four scientific consultants to oversee and perform an indoor air monitoring study. These scientists and their affiliations are:

John D. Spengler, Ph.D. (Environmental Health and Engineering, Inc.)

D. Warner North, Ph.D. (Decision Focus, Inc.)

Rudolph J. Jaeger, Ph.D. (Environmental Medicine, Inc.)

Douglas Smith, Sc.D. (ENSR Corporation, Consulting and Engineering Division).

The scope of this study was to measure the indoor air concentrations of the volatile organic chemicals which are known groundwater contaminants. The plan was to make these measurements in the Unifirst and Grace buildings and in several Woburn homes using multiple sampling and analysis methods. These measurements would then be critically reviewed to determine validity of results, identification of contaminant sources, and health significance of the indoor air concentrations. The overall purpose of this study was to address the question raised by DPH and to investigate whether groundwater contamination is, or is not, a significant source of indoor air contamination.

Independently, the U.S. Environmental Protection Agency (EPA) was requested to conduct an indoor air quality study in selected Woburn homes. Unifirst and Grace agreed to coordinate its study with EPA's and make all appropriate data available to EPA, DPH and the individual homeowners, in order to enhance the overall utility of the measurements. This report presents the results of the indoor and outdoor air sampling in three Woburn homes during April 25-27, 1989 conducted by ENSR Consulting and Engineering on behalf of GPH. The results of air sampling in the two commercial buildings will be presented separately in a subsequent report.

EPA selected, with DPH, the three subject homes for testing. According to EPA, the homes were selected to be representative of the Wells G&H study area, based on a survey of a larger number of homes. EPA and ENSR concurrently collected air samples in the basements of the three homes. ENSR collected additional samples on the first floor of each home and outdoors during each sampling session. To enable appropriate comparisons, EPA's data are presented together with ENSR's measurement results in this report.

It is known from other indoor air quality research studies that many volatile organic chemicals (VOCs), including some of the target compounds for this study, are ubiquitous in U.S. homes. Accordingly, it is important to present the Woburn data in the context of other available indoor air quality measurements. One of the largest national indoor air measurement programs was EPA's Total Exposure Assessment Methodology (TEAM) Study, the results of which are compiled and discussed in a three volume report (EPA/600/6-87/002). Results from the TEAM VOC study are presented here for comparison with the Woburn measurements.

Target Compounds

Five chemicals were specifically measured due to their presence in groundwater in the study area. The names of the five target compounds along with their common abbreviations ( ), are:

- Tetrachloroethylene (PCE)
- Trichloroethylene (TCE)
- 1,1,1-Trichloroethane (1,1,1-TCA)
- Trans-1,2-dichloroethylene (t-1,2-DCE)
- Vinyl chloride (VC)

EPA indicated that they would analyze their samples for a broader range of potential indoor air contaminants while focusing on the five target compounds. ENSR also analyzed certain samples for a limited number of additional compounds; compounds frequently detected in homes during the EPA TEAM Study. These supplemental compounds are:

- Benzene
- Toluene
- Xylene
- Chloroform
- 1,4-Dichlorobenzene
- Carbon Disulfide
- Ethyl Benzene
- Styrene
- n-Decane
- Methylene Chloride

Sampling and Analysis Methods

ENSR collected eight-hour samples by two methods:

i) Tenax sorbent tubes with Tenax/charcoal backup tubes. Tenax effectively adsorbs and retains many organic compounds in sampled air. Air was drawn through the tubes via personal sampling pumps. The tubes were thermally desorbed and analyzed by gas chromatography/mass spectrometry (GC/MS). Backup tubes were analyzed separately to assess whether breakthrough occurred. (If breakthrough occurred, appropriate correction factors would be applied to assure accurate results.)

ii) Whole air in Tedlar bags. Air was drawn into Tedlar bags via a special sampling pump arrangement that avoids passing sampled air through the pump itself. An aliquot of air from the bag was analyzed by gas chromatography (GC) using a series of detectors sensitive to each target compound.

ENSR also employed a third method to collect long-term samples. Passive charcoal organic vapor monitors were exposed for six to seven weeks in fixed locations. Each monitor now is being solvent extracted and analyzed by GC/MS by an outside laboratory. Analysis of these samples is not yet complete, and results will be reported later.

ENSR's Tenax method was similar to the Tenax method employed by EPA (EPA Standard Method T-01). The whole air (Tedlar) method has been enhanced by ENSR and has been approved by California's largest air pollution control agency (the South Coast Air Management District). Like EPA's Spherocarb method, the whole air samples were intended to provide the primary data for trans-1,2-dichloroethylene and vinyl chloride. All five target compounds were analyzed by both methods.

ENSR and EPA sampled in the three basements on the same days at exactly the same time. All systems were located side-by-side

in the same area of the basements. Upstairs samples in each home were collected by ENSR on the same day as the respective basement samples and during the same time frame. Each day, ENSR also collected eight-hour outdoor samples on a corner of the Unifirst property which was selected to represent an ambient air background. All ENSR samples reported here were analyzed at one of ENSR's environmental analysis laboratories.

Results

Three of the five target compounds (PCE, TCE, and 1,1,1-TCA) were detected in all three homes. The results for these compounds are presented in Table 1 and Figures 1 through 3. Each figure presents the highest concentrations measured at each address in the basement (B), and upstairs (U), by ENSR (shaded bars), and by EPA (unshaded bars). Only ENSR collected samples outdoors and upstairs in each home; hence the single shaded bars at these locations. In addition, two other unshaded bars are shown to the right of each figure for comparison. These represent the results of the EPA TEAM VOC study from two locations: Devil's Lake, North Dakota (ND) and Greensboro, North Carolina (NC). Each TEAM bar shows the highest 12-hour "overnight personal air" concentration from 23 or 24 samples in each location. The median TEAM concentration values are also denoted on these two bars with a dashed line. These reference results were included to allow comparison of Woburn results with two other areas of the country for which similar data on indoor exposure exist; but neither of which had histories of groundwater contamination.

EPA's TEAM VOC study provides one of the best available data bases of indoor exposures to various VOCs, including the target compounds for this project. The TEAM study made measurements of personal air, drinking water, breath and outdoor air in locations across the U.S. in order to characterize complete human exposure

to chemicals in the environment by several exposure routes. Most relevant to the Woburn study are the TEAM overnight personal air data. TEAM sampled personal air with Tenax (the same medium used by EPA and ENSR in Woburn). The TEAM Tenax sampler was carried by participants in a special vest, designed to sample air near the breathing zone. The TEAM overnight personal air samples were generally collected from 6 PM to 6 AM, and essentially represented indoor air (85% of the participants did not go outdoors during these samples). The Devil's Lake, ND and Greensboro, NC TEAM sites are presented here since they are less industrial than other TEAM locations (e.g., Elizabeth and Bayonne, New Jersey and Los Angeles, California), and, therefore, most comparable to the Woburn locale.

As can be seen in Table 1, the other two target compounds were virtually undetectable in indoor air and not found in outdoor air. ENSR detected trans-1,2-dichloroethylene in only one location, the basement of REDACTED , and there only marginally above the detecion limit. EPA did not detect t-1,2-DCE in any samples. Vinyl chloride was never detected by either ENSR or EPA at any location.

Table 2 presents ENSR's results for the ten supplemental compounds. Results are shown for all samples analyzed for any of the supplemental compounds and which met quality control criteria for this program.

Discussion

In general, ENSR's and EPA's data are quite comparable. For example, maximum values of 1,1,1-TCA obtained by EPA were within 25% of those measured by ENSR. The greatest difference between ENSR and EPA maximum values were for PCE measurements. Here differences ranged from a factor of 1.5 to a factor of 3 for some measurements. This is reasonable given the range of methods used

and the relatively low concentrations detected. It is also notable that, while EPA never found quantifiable levels of TCE, all of the TCE concentrations detected by ENSR were near or below EPA's detection limit. The compound t-1,2-DCE was not detected by EPA at all and was only found in one ENSR sample at a level very close to EPA's specified limit of sensitivity. Vinyl chloride was not detectable by either EPA or ENSR at any location (with each laboratory reporting a detection sensitivity of 2 ppb). Thus, the data show good agreement within the limitations of each method.

The specific discussion of results presented here focuses primarily on the identified target compounds and their relationship to potential sources, particularly the potential contribution of vapors from contaminated groundwater. As can be seen by reviewing the attached graphs, all three homes exhibited similar levels of PCE and TCE and all concentrations were near the median values reported for the North Dakota and North Carolina TEAM study groups, and well below the highest TEAM values. The areas selected for the TEAM study homes were not believed to be affected by groundwater contaminants. The TEAM measurements were obtained with monitoring devices worn by the residents and would therefore be average values that included time spent upstairs and downstairs in subject homes.

The 1,1,1-TCA indoor concentrations were also near or below the median TEAM values at all locations except the basement of REDACTED REDACTED, where the highest concentration measured was 25 ppb. While elevated relative to the other homes in this study, this concentration is within the range of the TEAM measurements, and, therefore, within the spread of "typical" indoor household exposures. The question regarding the potential for a groundwater source led to an examination of the well data for upgradient locations to determine whether 1,1,1-TCA was present. As reported by Geo Trans Inc. (see attached letter), no 1,1,1-TCA has been detected in more than 150 groundwater measurements taken between

the Grace Company property line and REDACTED , including Well S22 (a monitoring well located approximately 125 feet from REDACTED REDACTED . In addition, ENSR collected and analyzed a water sample from the sump in the basement of REDACTED . Although this water was believed to be surface runoff, measurements were examined in consideration of the groundwater - indoor air pathway question. No contaminants were detected at a detection limit of 2 ppb for the compounds of interest.

ENSR detected t-1,2-DCE in only one sample, in the basement of REDACTED at a very low concentration (0.57 ppb). This concentration is just above ENSR's specified detection limit (0.25 ppb). EPA did not detect t-1,2-DCE here, although their Spherocarb detection sensitivity was low enough (0.40 ppb) to detect the level reported by ENSR. Although this one value is viewed as somewhat questionable, there are several possible sources of trace levels of t-1,2-DCE, including:

- household product contents;
- analytical interferences or artifacts; and
- photodegradation of other constituents of the Tedlar bag sample.

The scientific consultants are actively researching these issues to better understand the apparent presence of t-1,2-DCE in this sample.

The presence of other air contaminants, such as methylene chloride, in relatively high concentration at REDACTED suggests a potentially significant non-groundwater emission source. Household products are the primary suspected sources for this chemical, since several containers of paints, thinners, waxes and automotive products were noted in the basement. Many solvent

mixtures also contain a relatively high percentage of 1,1,1-trichloroethane.

Conclusion

The indoor air quality measurement results obtained by ENSR and EPA for the identified chemicals have been reviewed with respect to the original study question concerning the possible contribution of groundwater contamination. It was determined that the two sets of measurements were consistent with each other within the expected range of variation for the low values measured. Both sets of results were also generally within the range of indoor air concentrations found in the EPA TEAM studies of homes in other areas where groundwater contamination is not expected to be a source.

One compound, 1,1,1-trichloroethane, was identified by EPA in its report as having higher concentrations in one home than EPA has routinely observed in other studies it has conducted. Comparison of this result with EPA TEAM data showed that these measurements were well below the maximum values found in the North Dakota TEAM study. They were comparable with the maximum value obtained in the North Carolina TEAM study. For this reason, further analysis was conducted for potential sources of this compound. Careful review of upgradient groundwater monitoring well data (150 tests) between the site boundary of the Grace facility and the home in which the highest results were found shows no evidence of 1,1,1-trichloroethane in any of these wells. Thus, it would appear that the observed concentrations are from other sources, the most likely of which would be stored household products containing this ingredient.

TABLE 1 WOBURN INDOOR AIR CONCENTRATIONS: TARGET COMPOUNDS

Sample Date	Sample ID	Address	Location	Sample Type (Vol)	PPBv - Target Compound Concentrations PCE *	TCE	1,1,1-TCA	t-1,2-DCE	VC
25-Apr-89	REDACTED	REDACTED	Basement	Tedlar Bag ~12 l	1.1	0.065	2.8	ND	ND
25-Apr-89			Upstairs	Tedlar Bag ~12 l	0.34	0.14	2.2	ND	ND
25-Apr-89			Upstairs	Tenax ~12 l	0.46	ND	2.7	ND	ND
25-Apr-89	UF-B1	Unifirst Bldg	Outdoor 0-4 Hrs	Tedlar ~12 l	0.15	0.054	3.9	ND	ND
25-Apr-89	UF-B2	Unifirst Bldg	Outdoor 5-8 Hrs	Tedlar ~12 l	0.14	0.031	3.2	ND	ND
25-Apr-89	REDACTED	REDACTED	Field Blank	Tenax	ND	ND	ND	ND	ND
25-Apr-89	UF-B4	ENSR Lab	Zero Air	Tedlar	0.054	0.0075	0.37	ND	ND
26-Apr-89	REDACTED	REDACTED	Basement	Tedlar Bag ~12 l	0.63	0.16	14	0.57	ND
26-Apr-89			Basement	Tenax ~12 l	1.4	ND	20	ND	ND
26-Apr-89			Basement	Tenax ~6 l	0.92	ND	11	ND	ND
26-Apr-89			Basement Coloc.	Tenax ~12 l	0.85	ND	11	ND	ND
26-Apr-89			Basement Coloc.	Tenax ~6 l	0.78	ND	7.1	ND	ND
26-Apr-89			Upstairs	Tedlar Bag ~12 l	0.21	0.17	3.8	ND	ND
26-Apr-89			Upstairs	Tenax ~12 l	0.54	ND	4.9	ND	ND
26-Apr-89	UF-B6	Unifirst Bldg	Outdoor 8 Hrs	Tedlar ~12 l	0.088	0.049	2.3	ND	ND
26-Apr-89	REDACTED	REDACTED	Field Blank	Tenax	ND	ND	ND	ND	ND
26-Apr-89			Field Blank	Tenax	ND	ND	ND	ND	ND
26-Apr-89			Sump Water	Water	ND	ND	ND	ND	ND
26-Apr-89	UF-B7	ENSR Lab	Zero Air	Tedlar	0.025	0.043	1.3	ND	ND
27-Apr-89	REDACTED	REDACTED	Basement	Tedlar Bag ~12 l	0.58	0.10	2.0	ND	ND
27-Apr-89			Basement Coloc.	Tenax ~12 l	1.9	ND	1.6	ND	ND
27-Apr-89			Upstairs	Tedlar Bag ~12 l	0.67	0.16	1.7	ND	ND
27-Apr-89			Upstairs	Tenax ~6 l	ND	ND	ND	ND	ND
27-Apr-89	UF-B10	Unifirst Bldg	Outdoor 8 Hrs	Tedlar ~12 l	0.36	0.08	3.1	ND	ND
27-Apr-89	UF-H3(F)	Unifirst Bldg	Outdoor (High)	Tenax ~12 l	1.9	ND	8.5	ND	ND
27-Apr-89R		REDACTED	Field Blank	Tenax	ND	ND	ND	ND	ND
27-Apr-89	UF-B13	ENSR Lab	Zero Air	Tedlar	0.035	0.049	0.59	ND	ND

Notes:

* PCE (tetrachloroethylene) values for Tedlar bag samples have been adjusted to reflect the average recovery of 67% measured in spiked samples. All other concentration values are presented without adustment for recoveries.

** Concentrations for this water sample are presented in units of PPBm (by mass)

ND: Not detected

Method Detection Limits

	PCE	TCE	1,1,1-TCA	t-1,2-DCE	VC
Tedlar Bags	0.010	0.015	0.010	0.25	2.0
Tenax (12 Liter)	0.3	0.4	0.4	0.5	0.8
Tenax (6 liter)	0.6	0.7	0.7	0.9	1.5
Water (PPBm)	2.0	2.0	2.0	2.0	10

Key to Abbreviations:

PCE:	Tetrachloroethylene
TCE:	Trichloroethylene
1,1,1-TCA:	1,1,1-Trichloroethane
t-1,2-DCE:	trans-1,2-Dichloroethylene
VC:	Vinyl chloride

TABLE1+ 19-Jul-89
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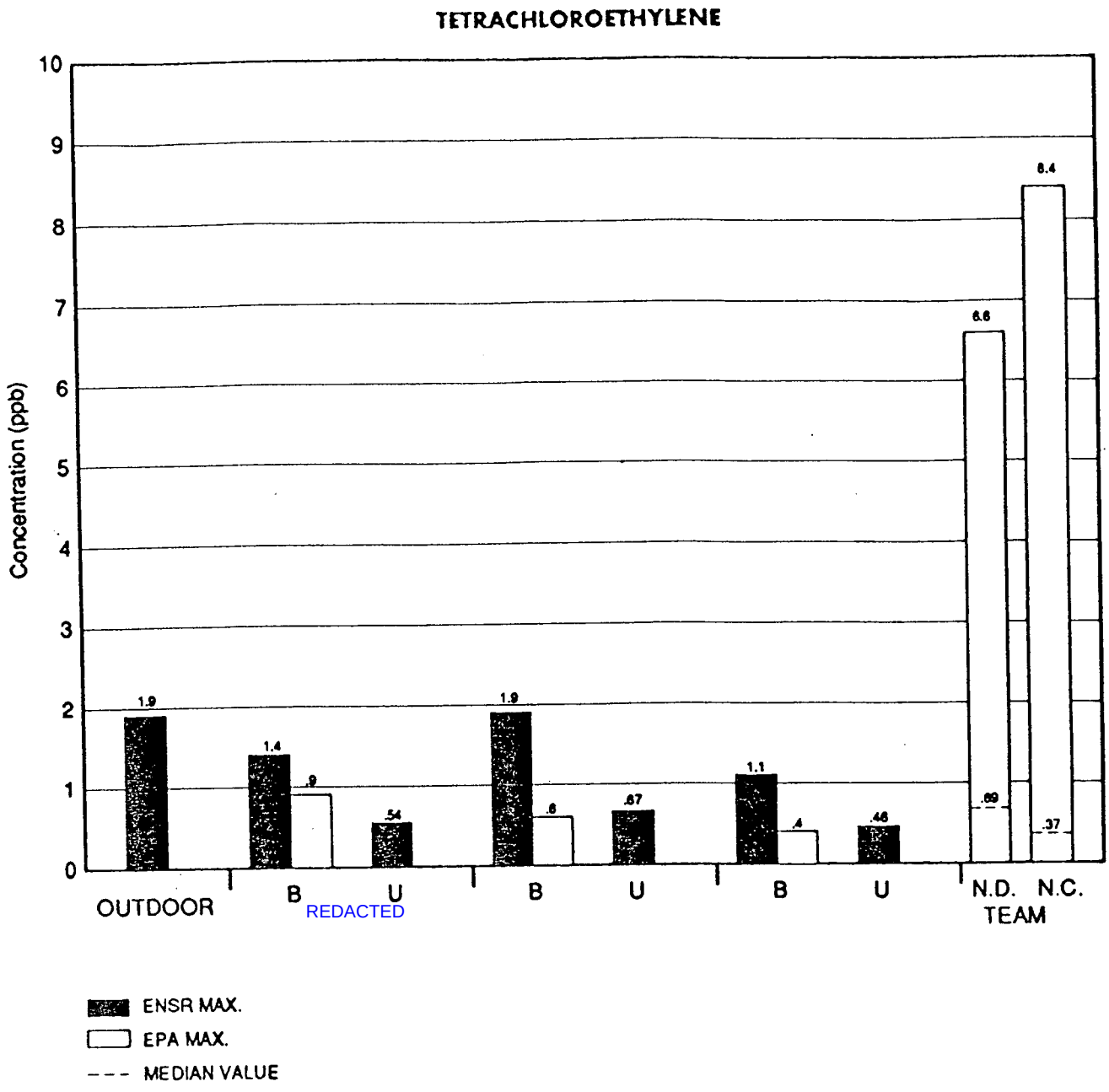
TABLE 2 WOBURN INDOOR AIR CONCENTRATIONS: SUPPLEMENTAL COMPOUNDS

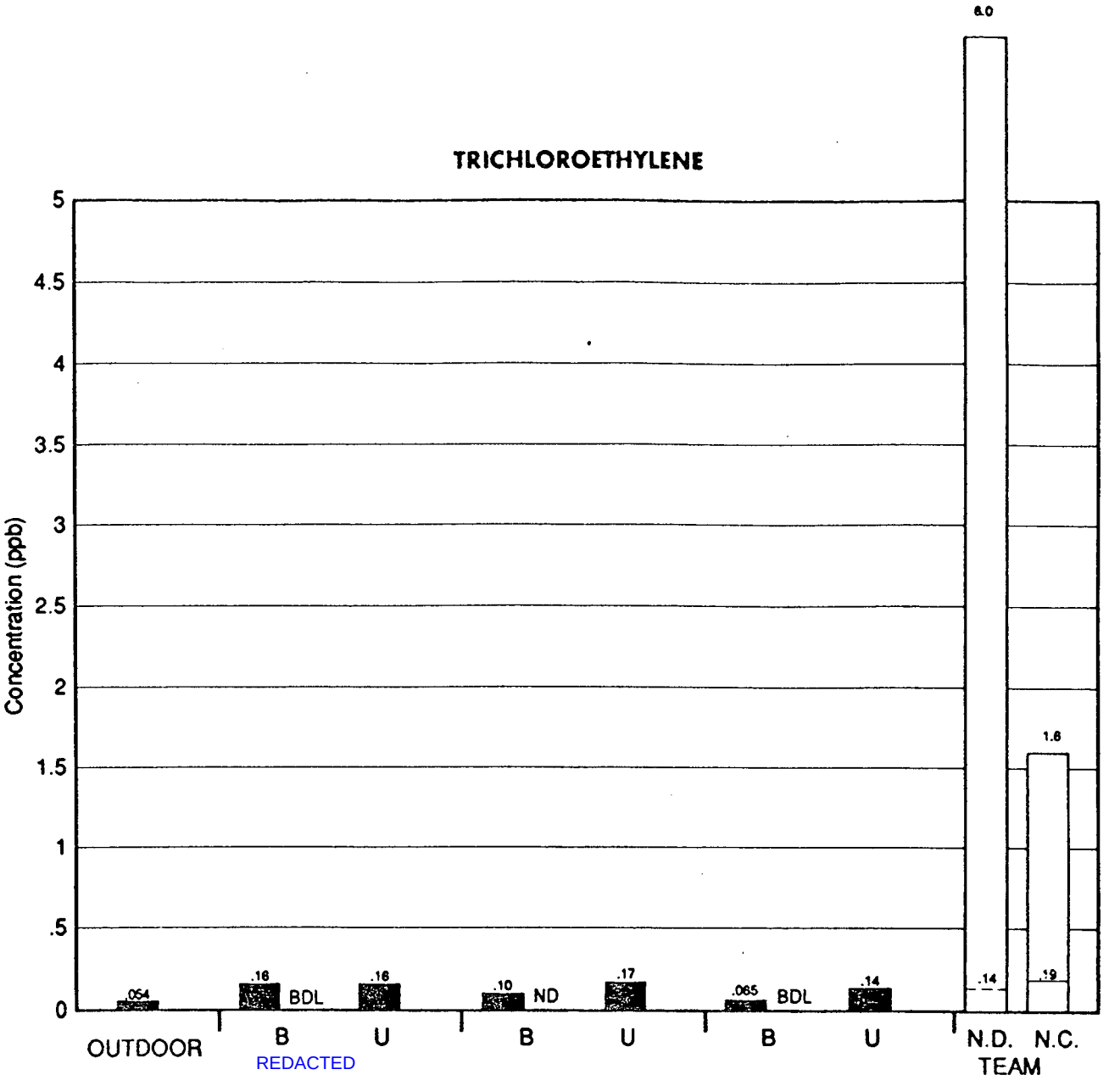
Sample Date	Sample ID	Address	Location	Sample Type (Vol)	PPBv - Target Compound Concentrations: Benzene	Toluene	Xylene	Chloroform	1-4,Dichloro-benzene	Carbon Disulfide	Ethyl Benzene	Styrene	n-Decane	Methylene Chloride
REDACTED														
25-Apr-89			Basement	Tedlar Bag ~12 l	ND	NA	ND	NA	NA	NA	NA	NA	NA	NA
25-Apr-89			Upstairs	Tedlar Bag ~12 l	ND	NA	ND	NA	NA	NA	NA	NA	NA	NA
25-Apr-89			Upstairs	Tenax ~12 l	0.73	2.4	0.52	ND	NA	NA	ND	ND	NA	NA
25-Apr-89	UF-B1	Unifirst Bldg	Outdoor 0-4 Hrs	Tedlar ~12 l	ND	NA	ND	NA	NA	NA	NA	NA	NA	NA
25-Apr-89	UF-B2	Unifirst Bldg	Outdoor 5-8 Hrs	Tedlar ~12 l	ND	NA	ND	NA	NA	NA	NA	NA	NA	NA
25-Apr-89	REDACTED		Field Blank	Tenax	ND	ND	ND	ND	NA	NA	ND	ND	NA	NA
25-Apr-89	UF-B4	ENSR Lab	Zero Air	Tedlar	ND	NA	ND	NA	NA	NA	NA	NA	NA	NA
REDACTED														
26-Apr-89			Basement	Tedlar Bag ~12 l	2.1	NA	8.5	NA	NA	NA	NA	NA	NA	NA
26-Apr-89			Basement	Tenax ~12 l	2.5	12	5.3	0.8	ND	0.64	1.5	ND	ND	37
26-Apr-89			Basement	Tenax ~6 l	1.5	7.0	3.1	ND	ND	1.3	0.94	ND	ND	90
26-Apr-89			Basement Coloc.	Tenax ~12 l	1.4	7.1	2.8	0.44	ND	0.96	0.86	ND	ND	130
26-Apr-89			Basement Coloc.	Tenax ~6 l	ND	5.9	2.5	ND	ND	2.5	0.9	ND	ND	38
26-Apr-89			Upstairs	Tedlar Bag ~12 l	1.8	NA	7.0	NA	NA	NA	NA	NA	NA	NA
26-Apr-89			Upstairs	Tenax ~12 l	2.1	7.6	2.2	ND	ND	ND	0.77	ND	ND	4.9
26-Apr-89	UF-B6	Unifirst Bldg	Outdoor 8 Hrs	Tedlar ~12 l	ND	NA	5.3	NA	NA	NA	NA	NA	NA	NA
26-Apr-89	REDACTED		Field Blank	Tenax	ND	ND	ND	ND	ND	0.99	ND	ND	ND	7.5
26-Apr-89			Field Blank	Tenax	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.84
26-Apr-89			Sump Water	Water	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND
26-Apr-89	UF-B7	ENSR Lab	Zero Air	Tedlar	2.8	NA	ND	NA	NA	NA	NA	NA	NA	NA
REDACTED														
27-Apr-89			Basement	Tedlar Bag ~12 l	ND	NA	6.7	NA	NA	NA	NA	NA	NA	NA
27-Apr-89			Upstairs	Tedlar Bag ~12 l	ND	NA	5.2	NA	NA	NA	NA	NA	NA	NA
27-Apr-89	UF-B10	Unifirst Bldg	Outdoor 8 Hrs	Tedlar ~12 l	ND	NA	ND	NA	NA	NA	NA	NA	NA	NA
27-Apr-89	UF-B13	ENSR Lab	Zero Air	Tedlar	ND	NA	ND	NA	NA	NA	NA	NA	NA	NA
Detection Limits:				Tedlar Bag	1.0	NA	5.0	NA	NA	NA	NA	NA	NA	NA
				Tenax (12 liter)	0.6	0.5	0.5	0.4	0.3	0.6	0.5	0.5	0.3	0.6
				Tenax (6 liter)	1.1	1.0	0.9	0.8	0.7	1.1	0.9	0.9	0.7	1.2
				Water (PPBm)	2.0	2.0	10	2.0	NA	2.0	2.0	10	NA	25

* Concentrations for this water sample are presented in units of PPBm (by mass)
NA: Not analyzed
ND: Not detected



RESIDENTIAL INDOOR AIR CONCENTRATIONS
IN WOBURN HOMES
ENSR AND EPA MEASUREMENTS

M890724



ENSR MAX.

EPA MAX.

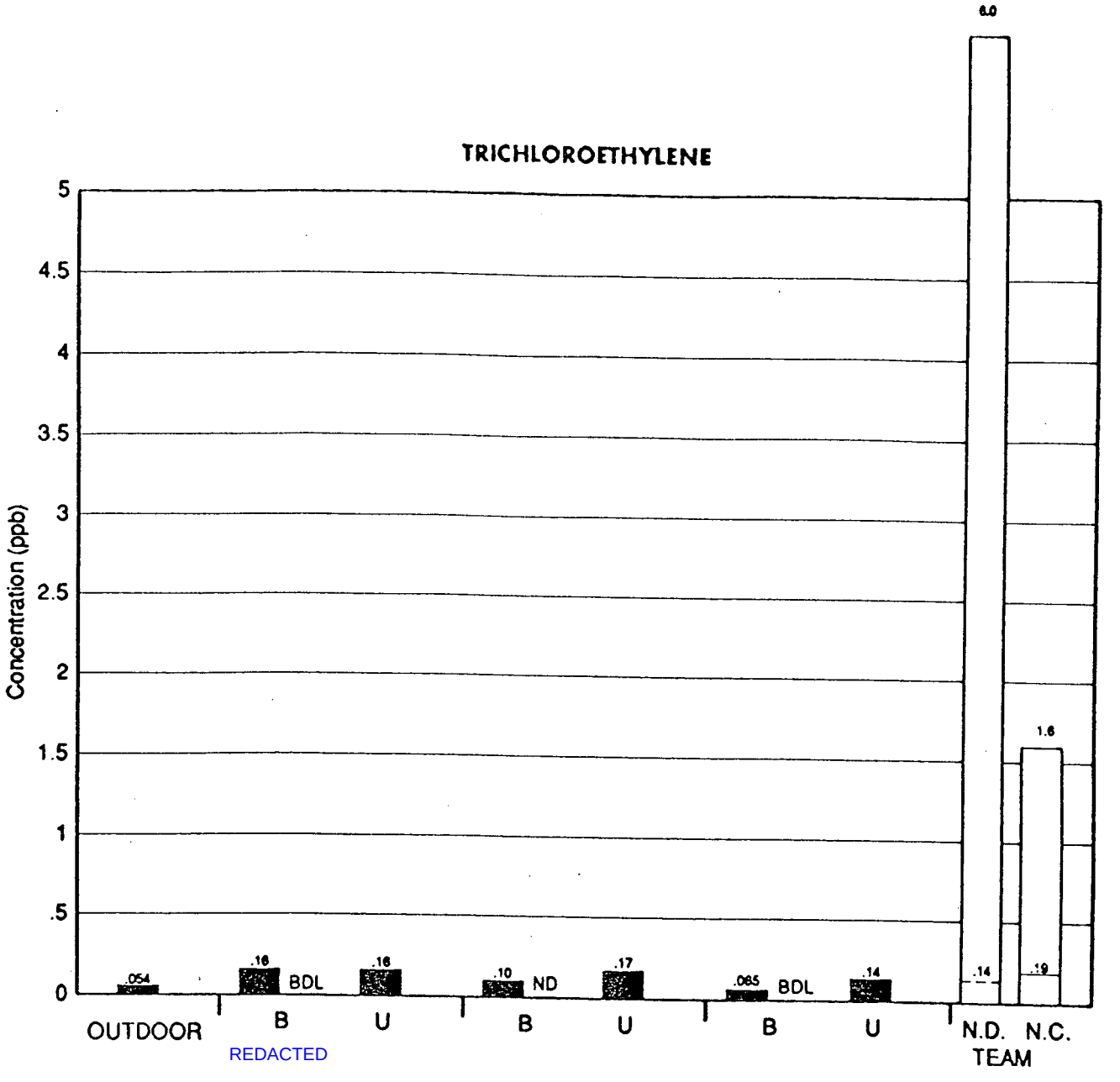
--- MEDIAN VALUE

ND NOT DETECTED

BDL BELOW DETECTION LIMIT OF 0.1 PPB

RESIDENTIAL INDOOR AIR CONCENTRATIONS
IN WOBURN HOMES
ENSR AND EPA MEASUREMENTS

M890723



ENSR MAX.

EPA MAX.

--- MEDIAN VALUE

ND NOT DETECTED

BDL BELOW DETECTION LIMIT OF 0.1 OR 0.2 PPB

RESIDENTIAL INDOOR AIR CONCENTRATIONS IN WOBURN HOMES ENSR AND EPA MEASUREMENTS

M890723